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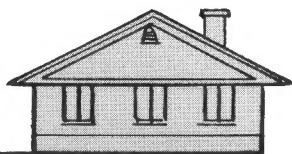
# Subterranean Termites

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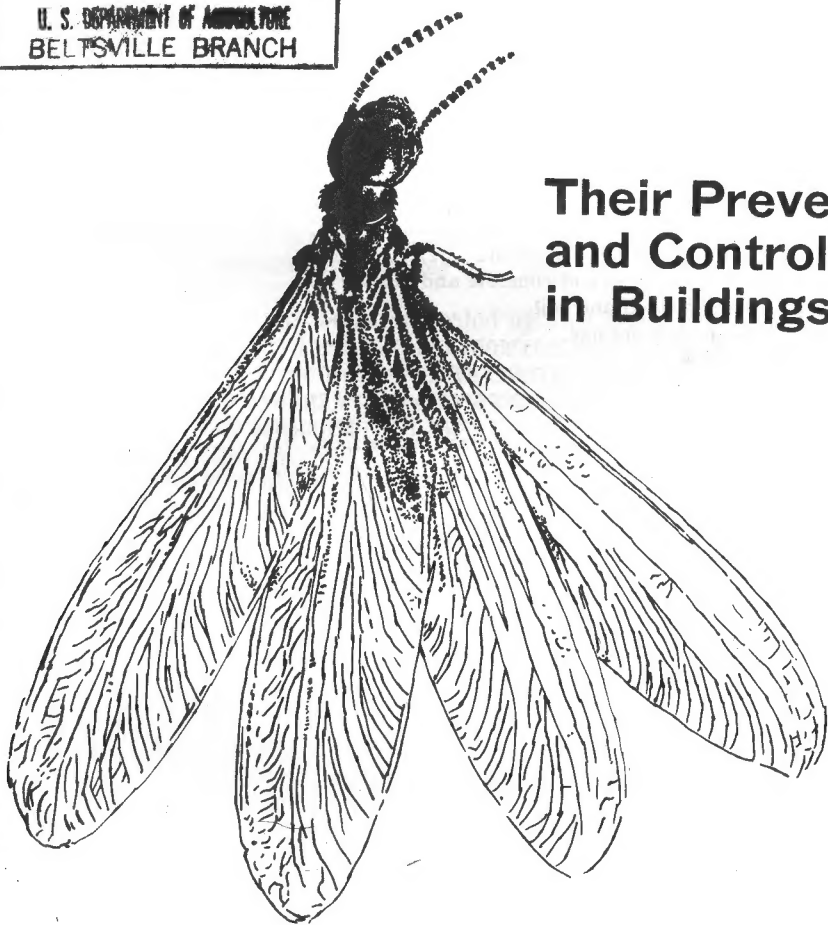
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**Their Prevention  
and Control  
in Buildings**



**Home and Garden Bulletin No. 64  
U.S. DEPARTMENT OF AGRICULTURE**

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     Farmers' Bulletin No. 1911, *Preventing Damage to Buildings by Subterranean Termites and Their Control*.  
     Farmers' Bulletin No. 1993, *Decay and Termite Damage in Houses* (regarding termite control).

# Subterranean Termites, Their Prevention and Control in Buildings

By R. A. St. George, H. R. Johnston, and R. J. Kowal, Division of Forest Insect Research, Forest Service

## INTRODUCTION

Subterranean, or ground-nesting, termites<sup>1</sup> cost the people of the United States many millions of dollars each year in repairs to structures and in control measures.

The termite problem is aggravated by the fact that much of the lumber on the market today is from young, second-growth trees which contain large amounts of sapwood. Such lumber is susceptible to termite attack. The extensive use of this kind of wood, together with deficiencies in building design and construction favorable to termites, greatly increases the danger of infestations in areas where this insect is found.

Buildings can be safeguarded against termite damage in the planning stage and during actual construction. Preventive measures in all new construction and effective control measures wherever termite infestations develop will decrease the waste of wood and wood products. Also, these measures will save the homeowner much anxiety and expense, later.

Increased use of concrete and masonry terraces adjacent to foundation walls and poorly designed slab-on-ground construction favor termite attack and result in mounting damage to buildings.

After a building has become infested with termites, it is often difficult and costly to apply effective control measures. Difficulties and costs vary among buildings. An infested building should be carefully examined to determine the extent of the infestation and the measures needed to prevent further damage. Some infested buildings require only simple structural changes, repairs, or chemical treatments, all of which can be made by the owner. Others may require such major changes or complicated treatment that they may need the services of a specialist who knows the habits of termites and is experienced in their control.

This bulletin suggests methods for preventing subterranean termite attack in new construction. When building or buying a new home, you may want to check these termite prevention features with the contractor. This publication tells also where to look for termites in existing buildings, how to recognize signs of their presence, and how to control them by both structural and chemical means.

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<sup>1</sup> Mainly genus *Reticulitermes*.

# TERMITES—THEIR APPEARANCE, BIOLOGY, AND HABITS

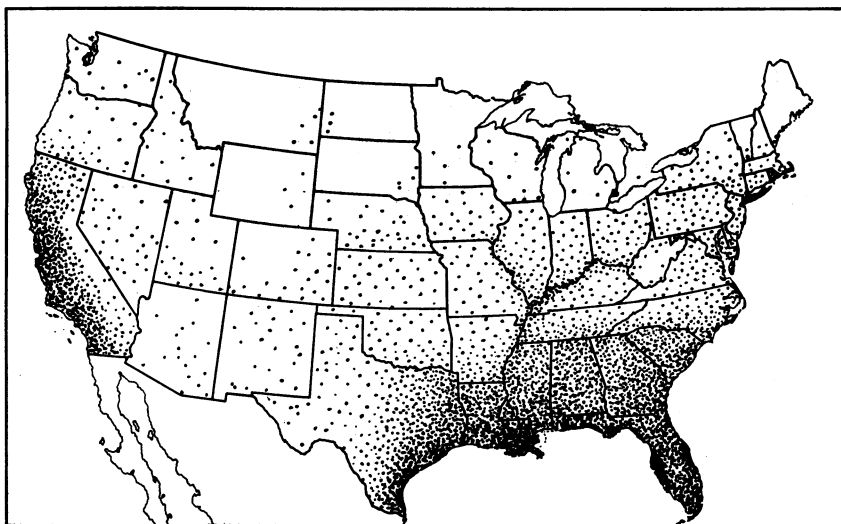
## Distribution of Termites

Subterranean termites are found practically throughout the tropical and temperate parts of the world. They are common throughout most of the eastern half of the United States and along the Pacific coast. The danger of infestation by these termites in different regions, based upon experience and reports of damage received by the Forest Service, is shown in figure 1. Hazard also varies greatly within a general area. In any specific locality it depends upon such factors as nature of soil, moisture conditions, and local building practices.

Subterranean termites probably have existed in their present distribution for millions of years. There is no evidence of their general introduction or spread from the tropics to the United States, or of widespread movement of any of our native species from the southern to the northern States. Infestations in buildings, however, have become more common with the general adoption of central heating plants. Heated basements can prolong the period of termite activity. This fact, together with other changes in building practices and use of construction materials, explains why termites have become a problem in areas where formerly they were of little importance. The vast development of suburban homes in forested areas likewise has aggravated the termite problem.

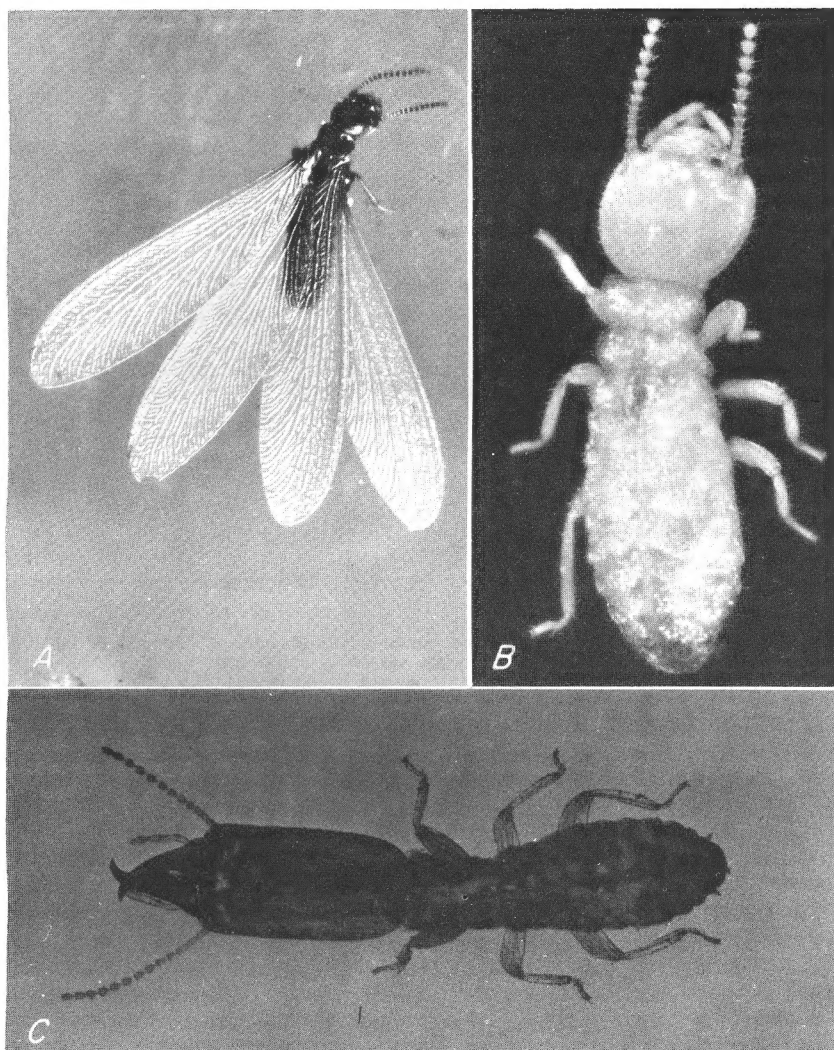
## How to Recognize Subterranean Termites

Subterranean termites are social insects that live in nests, or colonies, in the ground. Each colony is made up of three forms or castes—reproductives, workers, and soldiers (fig. 2). During their lifetimes,



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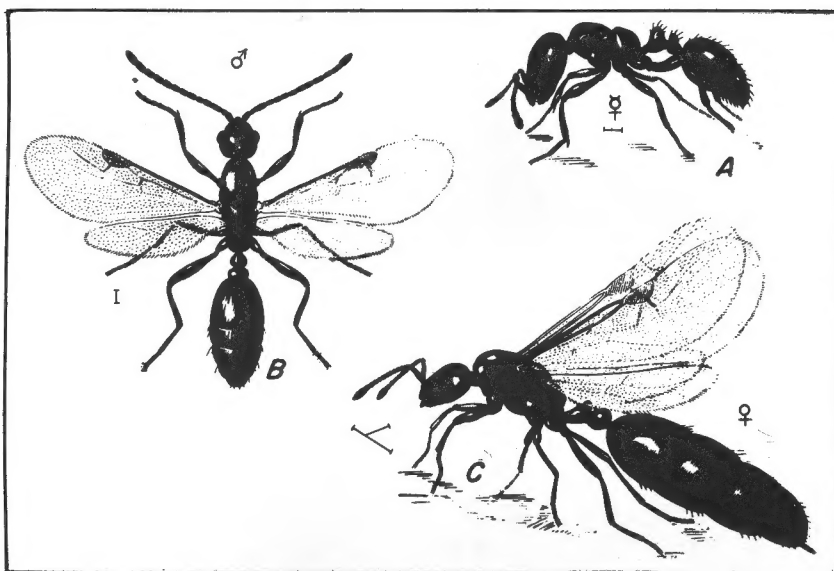
Figure 1.—Relative hazard of termite infestation in United States is indicated by density of stippling.



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**Figure 2.**—Winged sexual adult, or reproductive (A), adult worker (B), and adult soldier (C) of the eastern subterranean termite.

the individuals of each caste pass through three stages—egg, nymph, and adult. The adult workers and soldiers are wingless, grayish white, and similar in appearance. The soldiers, however, have much larger heads and longer mandibles, or jaws, than the workers. The worker is the insect that destroys wood and is the one usually seen when a piece of infested wood is examined. The soldier guards the colony. The reproductives, or sexual adults, have yellow-brown to black bodies and two pairs of long, whitish, opaque wings of equal size. They differ from the reproductive forms of true ants (fig. 3), which have two pairs of transparent wings of unequal size. Termites have thick waistlines. In contrast, ants, which often are mistaken for termites, have thin waistlines.

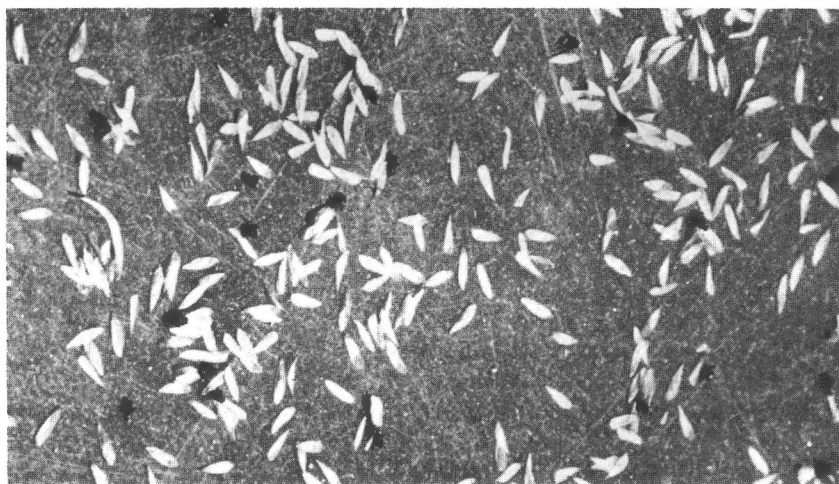


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Figure 3.—Worker adult (A) and winged sexual adults (B, male; C, female) of the little black ant.

## How to Recognize the Presence and Work of Termites

Large numbers of winged reproductive termites emerging or swarming from the soil or wood may be the first indication of the presence of a termite colony. Even though the actual flight of these adults is not observed, the presence of their discarded wings (fig. 4) is very



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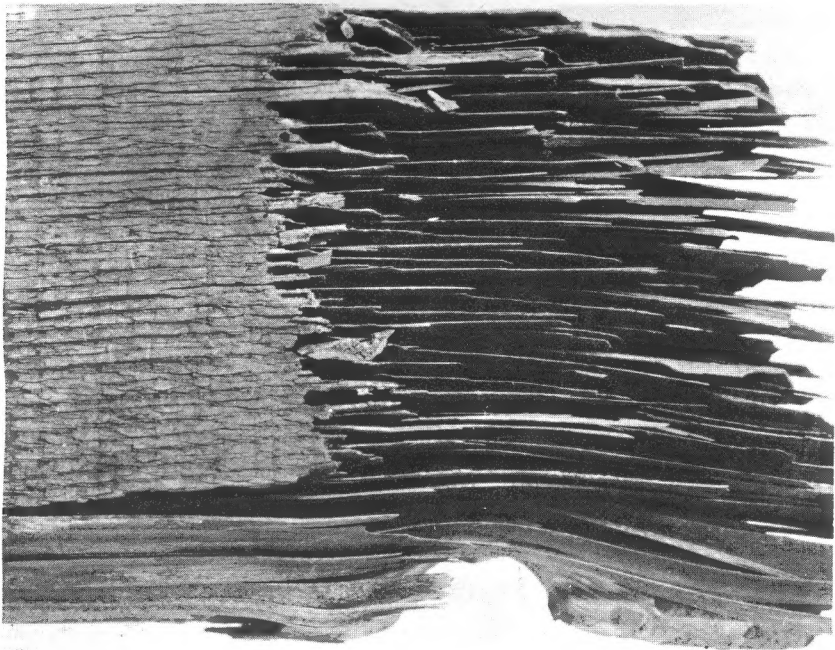
Figure 4.—Winged adult termites and discarded wings—proof of the presence of a colony nearby.





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**Figure 5.**—Siding removed to reveal hidden termite damage in wood on top of concrete slab on ground. The slab was poured in two units and entry was made through the expansion joints.



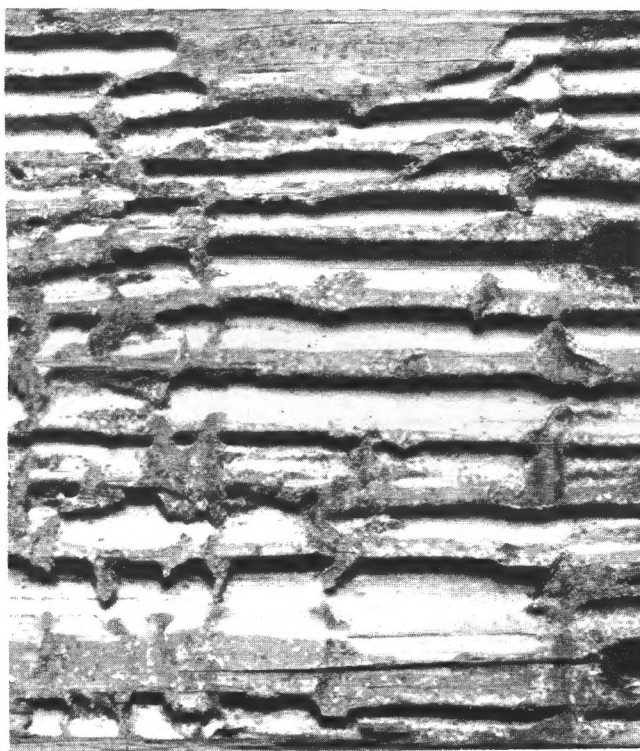
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**Figure 6.**—Wood honeycombed by termites. A portion of the exterior surface has been removed to reveal the extensive tunneling within, along the grain.

good evidence of a well-established colony nearby. These discarded wings often are found on the floor beneath doors or windows where termites have emerged within a building and have been unable to escape.

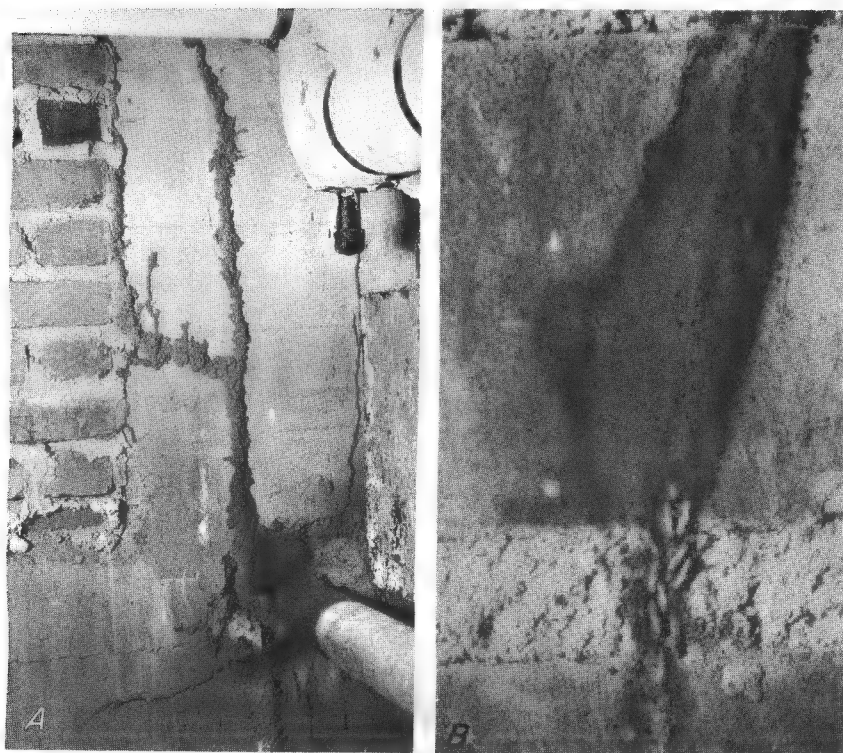
Termite damage to wood often is not noticeable on the surface. The wood must usually be stripped of its exterior in order to see the extent of damage (fig. 5). The workers avoid exposure to air by constructing galleries within the materials which they attack. Occasionally, they completely honeycomb wooden timbers, leaving little more than a thin shell (fig. 6). The inside of their galleries is covered with grayish specks of excrement and earth (fig. 7). Subterranean termites do not reduce the wood to a powdery mass or push wood particles to the outside, as do certain other types of wood-boring insects (see page 29).

The presence of flattened, earthen, shelter tubes which these insects construct over the surface of foundation walls is another sign of termite infestation (fig. 8). These tubes are from one-fourth to one-half inch or more wide. Termites use them as passageways between the wood and the soil from which they obtain essential moisture. The tubes also protect termites from the drying effect of direct exposure to air.



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**Figure 7.**—Surface of wood removed to show wood damage and the specks of excrement on the walls of the galleries.



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**Figure 8.**—A, Shelter tubes of termites entering void in wall around pipe and constructed over surface of the foundation; B, portion of a tube removed to expose termites.

## Development of a Termite Colony

Flights of termites occur most frequently after the first warm days of spring, often following a warm rain. They may also occur at almost any time during the spring or summer, and sometimes even in the fall, especially in warm parts of the country. In buildings with heated basements, termites occasionally fly during the winter. The individuals in these flights are adult winged reproductives, sometimes called kings and queens, that have developed in well-established colonies. They are attracted by strong light, and when they emerge within buildings they gather about windows or doors. Here they soon shed their wings. Then, pairs of termites try to return to the soil to find a suitable location for starting a new colony.

Most of these perish, but some pairs survive and succeed in hollowing out small cells in or near wood in the ground. After this is done, the female begins laying eggs. During the first year she lays only a few. The young termites hatching from these eggs are cared for by the parents and develop into workers and soldiers. These gradually take over most of the duties formerly performed by the original royal pair.

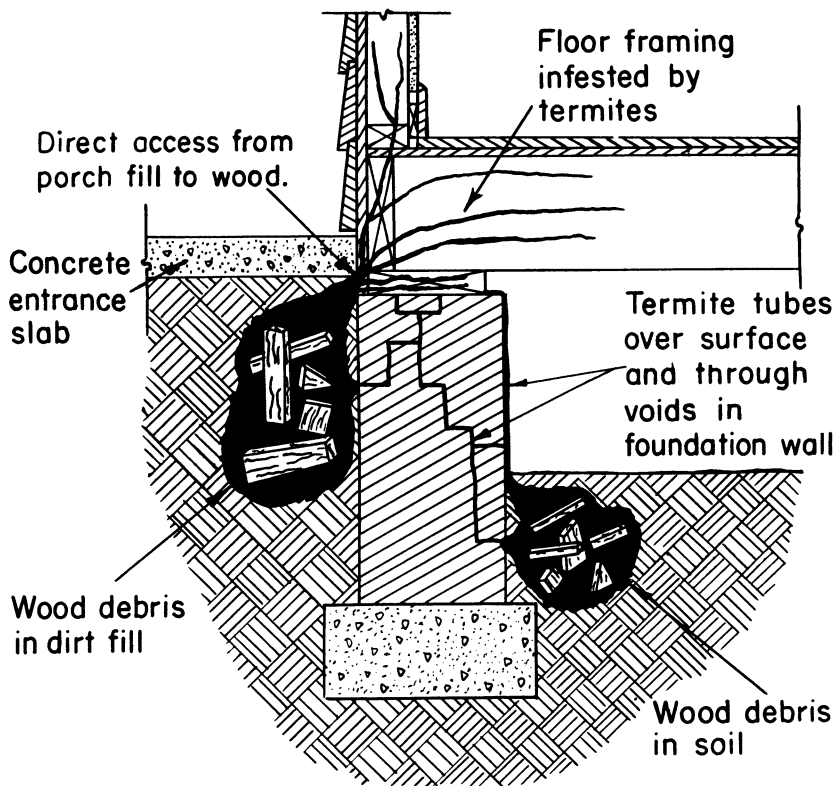
Egg laying increases rapidly in a termite colony after the first 2 or 3 years. Secondary reproductive forms, without wings, also develop

and lay eggs, which serve to supplement those of the original queen. A colony more than 5 or 6 years old may contain the royal pair, secondary reproductives, soldiers, and thousands of workers.

### Conditions That Favor Termite Infestation

Subterranean termites become most numerous in moist, warm soil containing an abundant supply of food in the form of wood or other cellulose material. They often find such conditions beneath buildings where the space below the first floor is poorly ventilated and where scraps of lumber, form boards, grade stakes, stumps, or roots are left in the soil. Most termite infestations in buildings occur because wood touches or is close to the ground, particularly at porches, steps, or terraces (fig. 9). Cracks or voids in foundations and concrete floors make it easy for termites to reach wood that does not actually touch the soil. Termite activity is increased and prolonged, even in northern areas, when soil within or adjacent to heated basements is kept warm throughout most of the year.

Conditions under which termite colonies thrive are rather rigid. More is required than the mere existence of a wooden structure.



F-489267

Figure 9.—Termite colonies can develop in wood debris and soil and gain entrance into a building, particularly at concrete entrance slabs of porches.

Much depends on how the structure is built. For example, unless it is possible for the termites in a building to maintain contact with the ground they will die. Because of this, certain steps taken during the construction of a building will greatly reduce or prevent future termite damage. These steps are outlined in the section Prevention of Termite Attack During Construction.

## Kinds of Materials Damaged by Termites

The principal food of subterranean termites is cellulose, obtained from wood and other plant tissues. Termites, therefore, are destructive to the woodwork of buildings, to telegraph poles, fence posts, or any other wood-product. They also damage paper, fiberboard, and various types of fabrics derived from cotton and other plants. Many noncellulose materials, including plastics, may be penetrated and damaged by termites, even though they do not serve as food. Termites also occasionally injure living plants. The greatest economic loss, however, is to the woodwork of buildings.

## PREVENTION OF TERMITE ATTACK DURING CONSTRUCTION

**The best time to provide for protection against subterranean termites is during the planning and construction of a building.** This has been found out through long years of research on the habits and behavior of termites and through experience in their control.

Improper design and construction of buildings, resulting perhaps from lack of knowledge of or indifference to the termite problem, are favorable to infestation.

One of the most susceptible types of construction, and one that often gives a false sense of security, is the concrete slab-on-ground. Termites can gain access to the building over the edge of the slab, or through expansion joints, openings around plumbing, and cracks in the slab. Infestation in buildings with this type of construction is most difficult to control.

## Sanitation and Structural Preventive Methods

*Wood in the soil.*—Remove all tree roots, stumps, or other wood debris from the building site before construction work is started.

Remove spreader sticks and grade stakes before the concrete sets. Remove form boards and scraps of lumber before filling or back-filling after the foundation is completed. Do not bury wood beneath porches, terraces, and steps (fig. 9). Do not permit scraps of lumber to remain on the surface of the soil beneath or around buildings. If no wood is left in or on the soil, the danger of a large termite colony developing and infesting the building is reduced.

*Drainage beneath buildings.*—Prevent moisture from accumulating in the soil beneath a building. The soil surface should be sloped so that surface water will drain away from the building; eave gutters and downspouts connected to a storm sewer system are very helpful. Place drainage tile around the outside of buildings with basements.

## Types of Foundations

All foundations should be made as impervious to termites as possible to prevent hidden attack on woodwork above. This is one of the most important protective measures and should be considered very carefully in all construction. Foundations may be rated in the order of relative resistance to penetration by termites as follows:

1. Poured concrete foundations (fig. 10), properly reinforced, prevent large shrinkage or settlement cracks. (Cracks  $\frac{1}{32}$  inch or more in width will permit the passage of termites).
2. Hollow-block or brick foundations and piers:
  - a. Capped with a minimum of 4 inches of reinforced poured concrete (fig. 11).
  - b. Capped with precast solid-concrete blocks, all joints completely filled with cement mortar or poured lean grout.
  - c. Top course of blocks and all joints completely filled with concrete. (Where hollow blocks are left open, no protection is provided.)
3. Wooden piers, or posts used for foundations or piers, pressure-treated with an approved preservative by a standard pressure process.

## Metal Termite Shields

Another method of preventing hidden entry is by means of termite shields, which can be used instead of the concrete cap or other methods

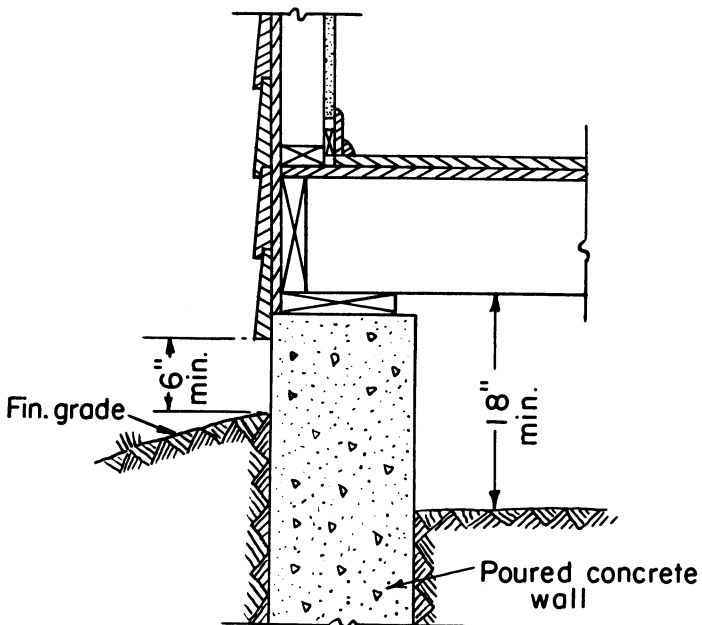
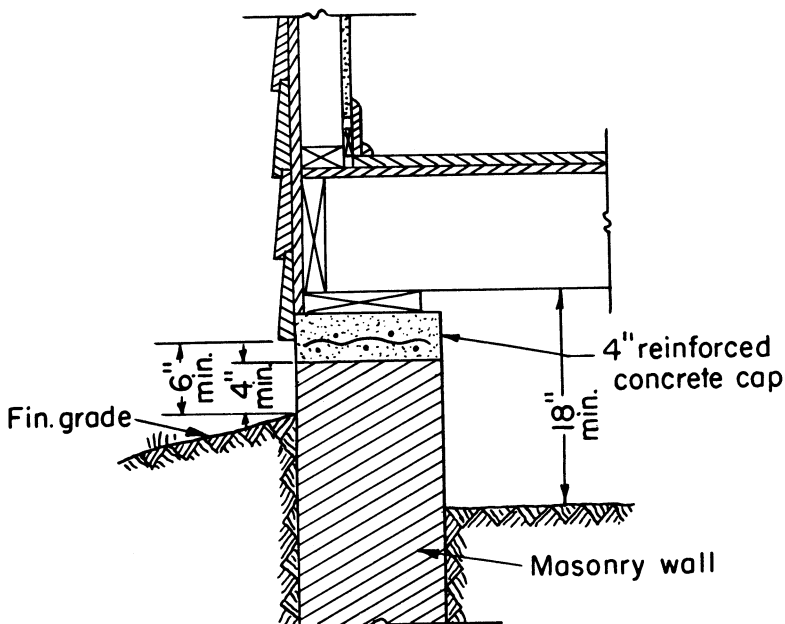


Figure 10.—Poured concrete foundation walls or piers that are easily inspected offer complete protection against hidden termite infestation.



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Figure 11.—A reinforced poured-concrete cap on masonry walls or piers prevents hidden attack by termites. A minimum clearance of 4 inches should be provided between the outside finished grade and the lower horizontal joint of the cap; also, a clearance of 6 inches from wood to ground. Minimum clearance of 18 inches under the floor joists will allow inspection for the presence of termite tubes or for possible cracking of the cap.

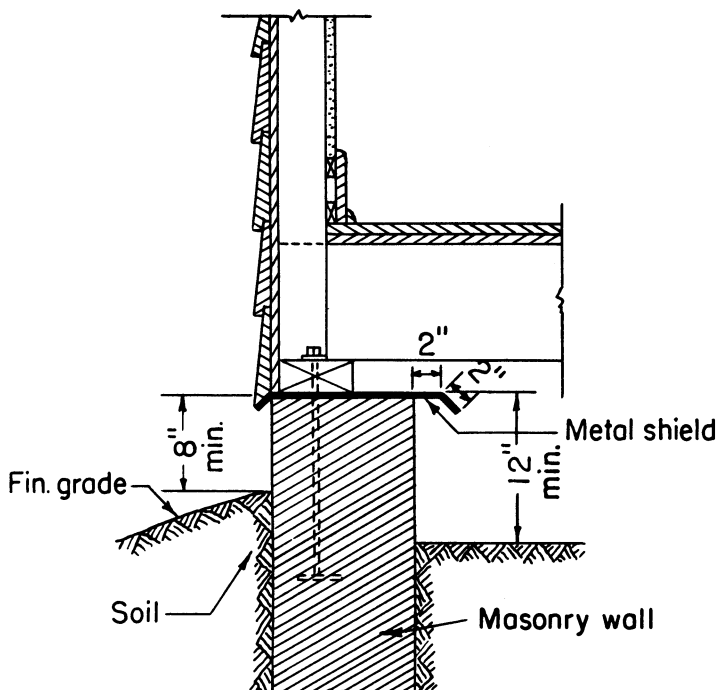
of sealing unit masonry foundations (fig. 12). Properly designed, constructed, installed, and maintained, metal shields will give a high degree of protection for many years. *However, experience has shown that good shield construction and installation is rare.* Also, no termite shield has yet been developed that is absolutely effective in preventing the passage of termites.

A properly made and installed shield will force the termites into the open, where they can be seen. Thus it will act as an effective barrier to hidden attack. Termites can construct tubes on the lower surface of a shield. Occasionally one of these tubes will extend around the edge and up over the upper surface. Frequent inspection for the presence of such tubes, therefore, is essential. If termites do succeed in getting past the shield, it may be necessary to apply a soil chemical.

Shields are used primarily for protecting portions of buildings above ground. They are best suited for unit masonry piers. They are not effective in safeguarding finished rooms in basements. Termites can enter these rooms through expansion joints, crevices in foundation walls, or cracks in the floor. Shields should not be installed in the slab-on-ground type of construction.

*Materials for shields.*—Do not use nonmetals for shields. The following materials are considered adequate at present:

- a. *Galvanized Iron.*—Should be copper-bearing or of an equivalent high-corrosion resistant material, 26 gage minimum.



F-489270

**Figure 12.**—Termite shield over uncapped masonry wall showing minimum clearance from ground on both inside and outside of foundation.

b. *Zinc*.—Is an acceptable shield material except in locations exposed to salt air, 0.024 inch minimum thickness.

c. *Copper*.—16 ounce, cornice tempered.

d. *Terneplate*.—1C or 1X, 40-pound coating, painted both sides.

*Construction and installation of shields*.—A properly formed and correctly installed shield meets the following requirements:

1. It is made continuous around the entire foundation regardless of change in level.
2. On interior parts of walls and piers it extends 2 inches horizontally and an additional 2 inches downward at a 45° angle (fig. 12). The projection may be reduced on exterior walls, because this surface is exposed and termite activity can be detected readily.
3. It must be used at least 12 inches above the ground beneath the building and at least 8 inches above on the exterior.
4. All joints are double locked. Seam or spot-soldered joints are riveted and sweated.
5. Holes cut through it for anchor bolts are sealed with roofing grade coal-tar pitch or rubberoid bituminous sealers. Common asphalts are not effective.

### Concrete Slab-on-Ground Construction

As previously indicated, slab-on-ground construction is extremely susceptible to termite attack, and infestations are very difficult to control. In this type of construction, pretreat the soil with chemicals before pouring the concrete. This will prevent termites from enter-



ing through expansion joints, around plumbing, and through cracks which may develop. Such a treatment, properly applied, will protect a building for many years.

Do not leave any untreated wood such as forms, scraps, grade stakes, or wood plugs in or beneath the slab. Reinforce the slab at all points where it is likely to crack.

Slabs vary in their susceptibility to penetration by termites. The *monolithic type* is the best one to use. In this type, the floor and the footing are poured in one continuous operation, so that there are no joints or other structural features which might permit hidden termite entry (fig. 13).

A second type is the *suspended slab* which extends completely across the top of the foundation. Here the slab and the foundation are constructed as independent units. This prevents hidden termite attack, even though a vertical crack may develop in the wall (fig. 14). Regardless of which is used, the top of the slab should be at least 8 inches above grade and its lower edge open to view.

A third type is the *floating slab*. It may either rest on a ledge of the foundation, or be independent of it. In both instances, the slab is in contact with the ground (fig. 15). This is the most hazardous of the three types of slabs. It comes in contact with the foundation walls where there are expansion joints, through which termites may gain access to the woodwork above.

To reduce penetration through expansion joints and openings made for plumbing and conduits, fill them with roofing grade coal-tar pitch or rubberoid bituminous sealers.

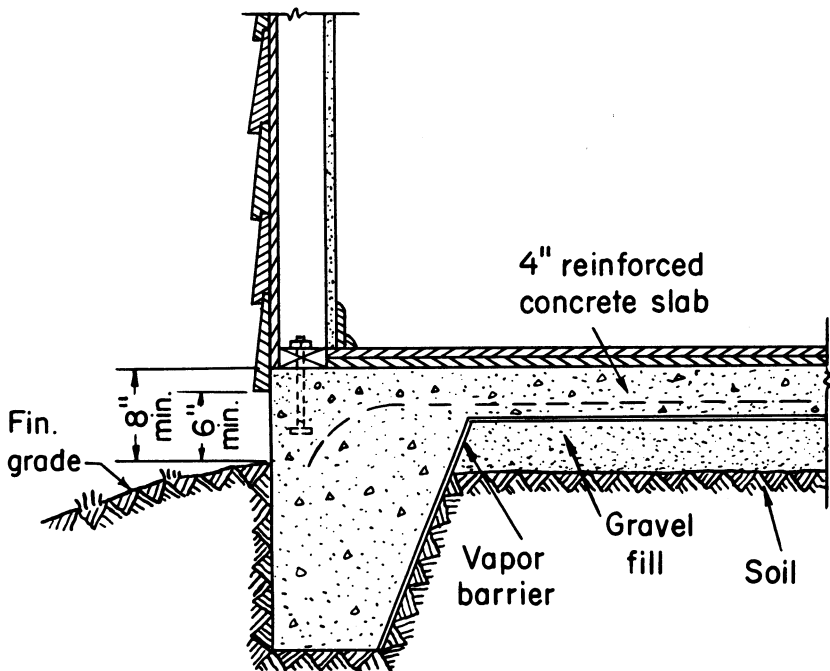
## **Raised Porches and Terraces of Concrete or Masonry**

Dirt-filled porches and terraces account for a large proportion of all termite infestations in buildings. Therefore, do not fill spaces beneath concrete porches, entrance platforms, and similar raised units with soil. If possible, leave such spaces open for inspection and provide access doors for that purpose. If this cannot be done, or if the spaces beneath such raised units must be filled, thoroughly treat the soil with chemicals. (See section on chemical preventive methods.)

## **Clearance Between Wood and Soil**

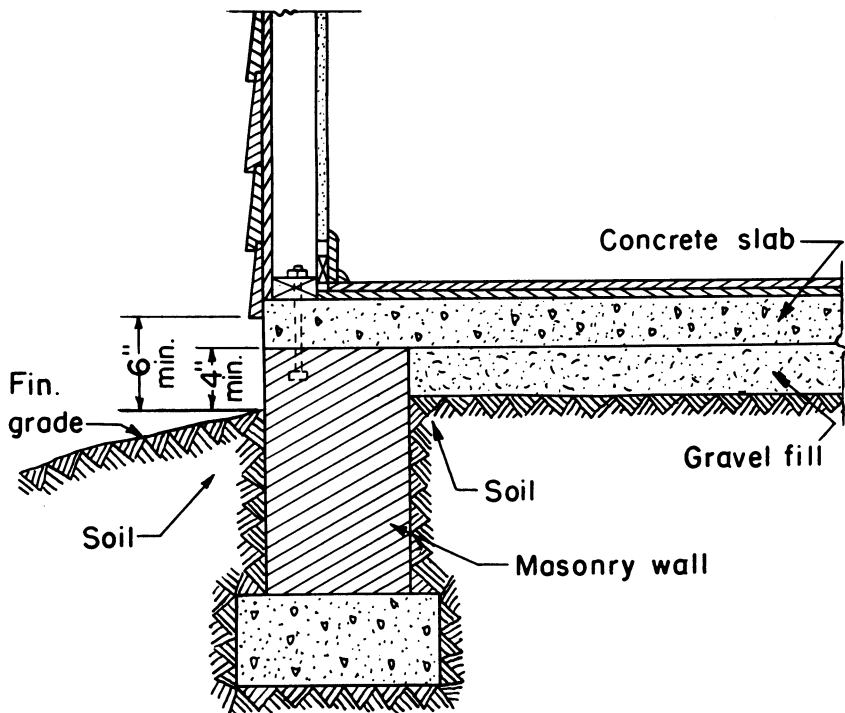
The minimum clearance between outside finish grade and the top of a floor slab should be 8 inches, with at least 6 inches exposed (fig. 13). In crawl spaces the minimum clearance between the ground and the bottoms of floor joists should be 18 inches; such clearance for beams and girders should be 12 inches (fig. 16).

Make the outside grade lines of houses with crawl spaces or basements at least 6 inches below all exterior woodwork to permit inspection of the outer surface of the foundation (fig. 11). Where the superstructure is of brick or other masonry, the grade line should be 8 inches below the top of the foundation for the same reason (fig. 16). If a masonry foundation is capped with 4 inches of reinforced concrete or with solid concrete blocks, the grade line should be at least 4 inches below the uppermost horizontal joint (fig. 11). This will force termites into the open, where they can be seen before they reach the wood. Such clearance also reduces the danger of decay.



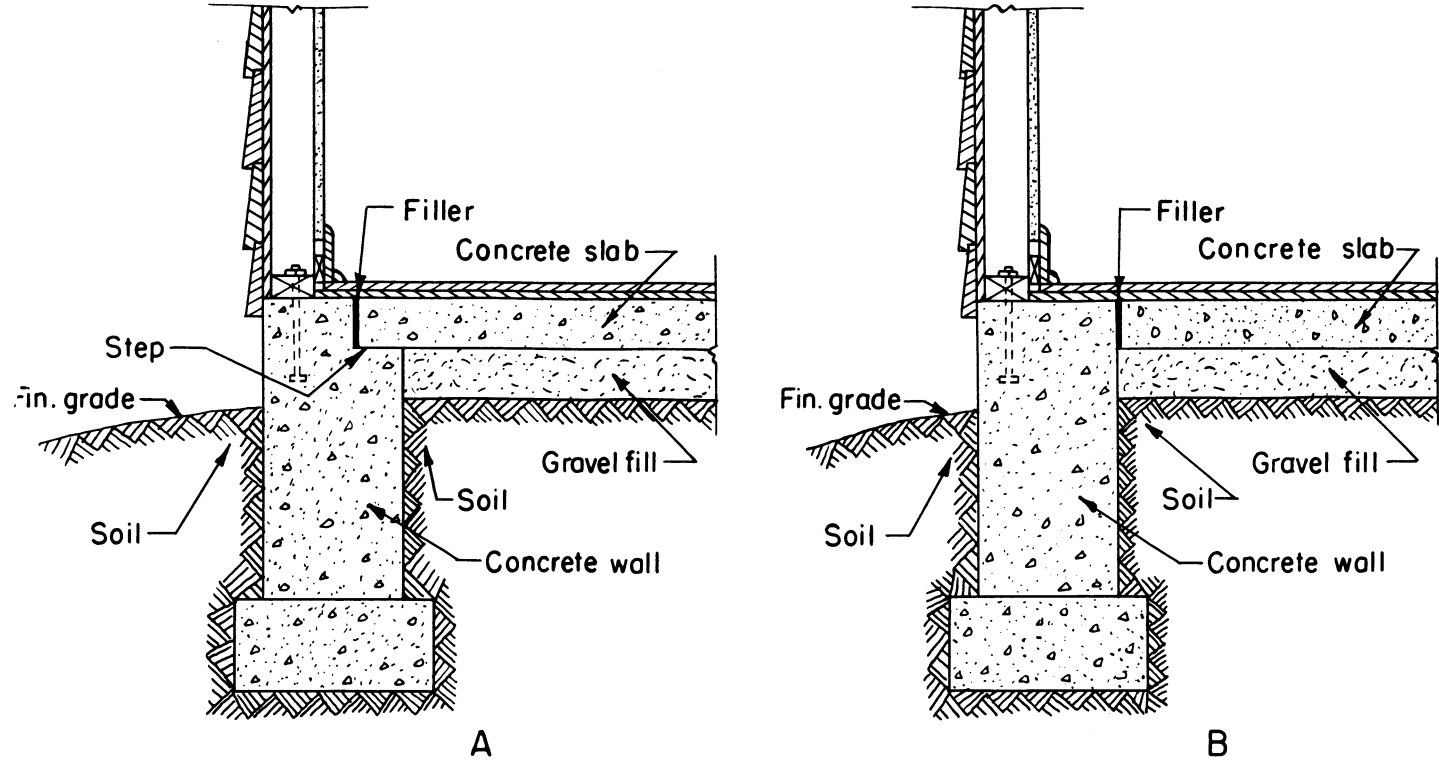
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Figure 13.—Monolithic concrete slab-on-ground construction.



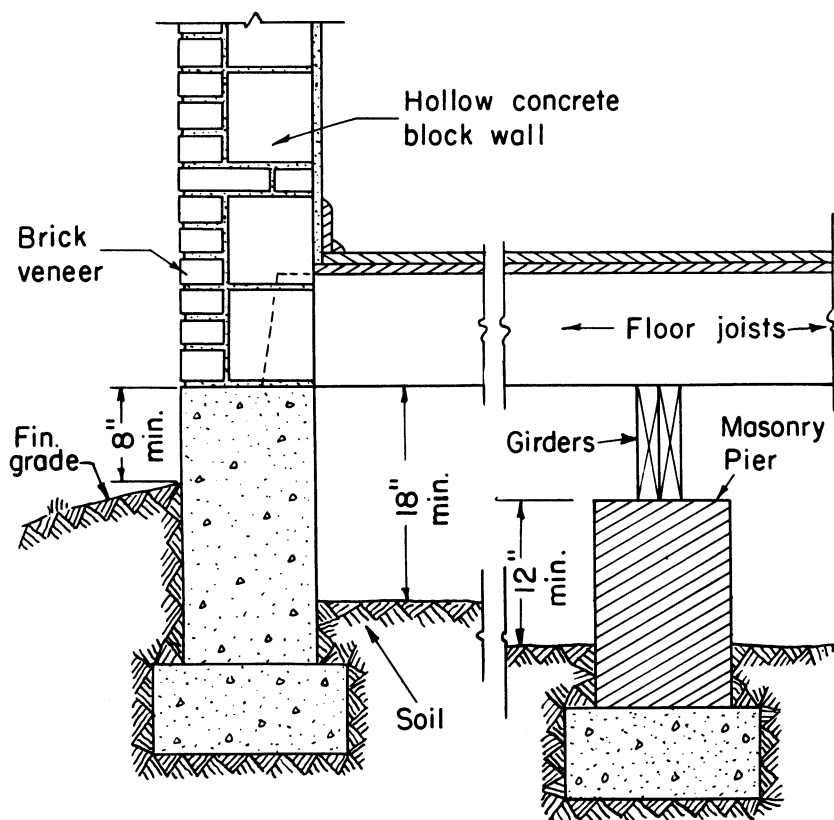
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Figure 14.—Suspended concrete slab-on-ground construction.



F-489273

Figure 15.—Floating concrete slab-on-ground construction: A, Edge of slab rests on ledge of the foundation wall; B, slab rests entirely on the ground (floating).



F-489274

**Figure 16.**—Where the superstructure of a building is masonry, provide for adequate clearance between wood and ground both outside and inside the building.

## Ventilation Beneath Buildings

Ventilation openings in foundation walls beneath buildings with crawl spaces should be large enough and so distributed as to prevent dead-air pockets from forming. These pockets give rise to humid conditions which favor termite activity. Openings placed within 10 feet of the corners of buildings usually give the best cross ventilation. The openings need not be placed on the front side of a building, provided they can be arranged to prevent the formation of unventilated areas. The size and number of openings depend on soil moisture, atmospheric humidity, and air movement. In general, the net free area of ventilation opening should be equivalent to  $\frac{1}{160}$  of the ground area beneath dwellings. Shrubbbery should be kept far enough from the openings to permit free circulation of air, and far enough from the foundation to allow inspection of wall surfaces for the presence of termite tubes.

## Exterior Woodwork<sup>2</sup>

*Wooden porches and steps.*—Porch supports, such as piers, adjacent to a building should be separated from the building proper by 2 inches to prevent hidden access by termites. Wooden steps should rest upon a concrete base or apron which extends at least 6 inches above grade (fig. 17).

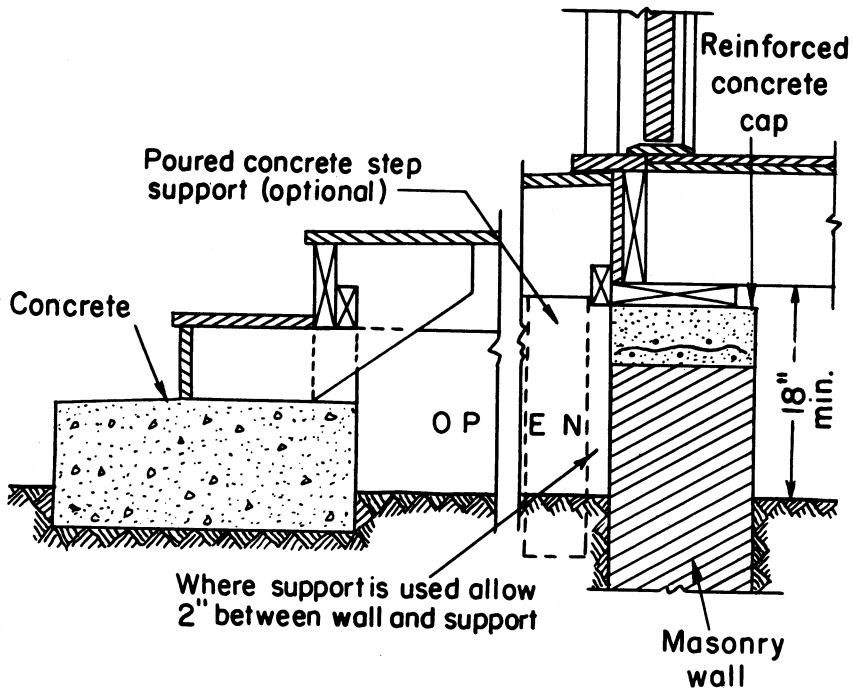


Figure 17.—Construction of wooden steps of porch to prevent hidden termite attack.

*Door frames.*—Door frames or jambs should not extend into or through concrete floors. This is true particularly for exposed outside doors.

*Windows below grade.*—Where window frames or other openings near or below outside grade are made of wood, the foundation wall surrounding the wood should be made impervious to termites, and the level of the bottom of the window well should be at least 6 inches below the nearest wood.

*Skirting between foundation piers.*—Where pier foundations are used, it is sometimes desirable to close the spaces between the piers with lattice or wooden skirting. If this is done, the woodwork should be separated from the piers and soil by at least 2 inches.

<sup>2</sup> Certain units of exterior woodwork are susceptible to decay and should be treated with a preservative. For information on this subject see page 19.

## Wood Used in Basements

*Partitions and posts.*—Place wooden basement partitions, posts, and stair carriages *after the concrete floor is poured*. They should never extend into or through the concrete; otherwise, they are subject to attack and damage by termites (fig. 18). Use reinforced concrete under them, also under heating units, and other load-bearing points; otherwise, the concrete may crack and let termites get through from the soil beneath. Concrete footings which extend at least 6 inches above the floor level should be used under wood posts, partitions, stair carriages, etc.



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**Figure 18.**—A, Damaged floor, paneling, and doorframe in basement apartment, as ■ result of improper insulation of wood from the ground; B, part of the doorframe shown in A.

*Basement rooms.*—Termite infestations in basement rooms are very difficult to detect and control. Such situations exist commonly in recreation rooms, and in finished basements where untreated wood floors and furring strips are used. The best way to prevent such infestations is to treat the soil below the basement floor and along the outside of the foundation; also, any voids that exist in the wall. Use the chemicals discussed on pages 19 to 21. Because of the danger of decay, wood screeds, subflooring, and furring strips should be chemically impregnated with a standard wood preservative.

*Girders, sills, and joists.*—Do not place wooden girders, sills, and joists in or on foundation walls in basements below the outside grade level. Termites may find hidden access to this wood; furthermore, the wood may also be affected by decay. Floor joists and girders, boxed in masonry concrete walls, should have an air space of at least 1 inch around the sides and ends. Because of the difficulty of removing these timbers once they are structurally damaged by termites, it is a good practice to use lumber impregnated with a preservative.

## Water Pipes and Conduits

Keep all plumbing and electric conduits clear of the ground in crawl spaces. Suspend them from girders and joists where possible. Do not support them by wooden blocks or stakes connecting with the ground, since termites can tunnel through these wood supports or construct tubes over them to the sills, floors, and joists above. Chemically treat the soil around plumbing that extends from the ground to the wood above.

Where pipes or steel columns penetrate concrete ground slabs or foundation walls, fill the spaces around them with either dense cement mortar, roofing grade coal-tar pitch, or rubberoid bituminous sealers.

## Chemically Treated and Naturally Resistant Woods

Chemically treated wood is an additional safeguard against damage by termites and decay. For maximum protection the wood should be pressure-impregnated with an approved chemical by a standard process. Vacuum treatment gives adequate protection where conditions are less severe. Brush, spray, or short-period soak treatments give limited protection to wood above ground. The chemicals and their uses are given in (1) Federal Use Specification TT-W-571d (current revision),<sup>3</sup> (2) Standards of the American Wood Preservers Association, and (3) Standards of the National Woodwork Manufacturers' Association.

The slow-growing heartwood of some of the native species of wood is quite resistant to termites, but it is not immune, nor is it as resistant as pressure-treated wood. So far as known, the following kinds and grades of lumber are the most resistant to termites:

1. Foundation-grade California redwood.
2. All-heart southern tidewater red cypress.
3. Very pitchy southern pine—"lightwood".
4. Heartwood of eastern red cedar (less resistant than the above).

## Chemical Preventive Methods

Chemical treatment of the soil around or under the foundation of buildings is one method of preventing termite attack. Soil treatment, however, should be used as a supplement to good construction, not as a substitute for it. Studies made by the United States Department of Agriculture show that certain chemicals added to the soil under buildings or around foundations will prevent or control termite infesta-

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<sup>3</sup> This specification is a part of Section IV, Part 5, of the Federal Standard Stock Catalog. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price 5 cents.

tions for many years. The formulations and dosages recommended here for such treatment are those which have been highly effective for about 10 years in field tests. These tests were made in south Mississippi, where termites are abundant. Some of the chemicals have not been tested long enough to determine the maximum years of protection they will give. They will probably remain effective for longer periods than indicated below.

### *Chemicals to Use for Soil Treatment*

In presenting these recommendations, the lowest effective concentrations or dosages of the chemicals mentioned have been doubled; in most instances, to provide an equitable margin of safety from termites for each one. Tests of some of the chemicals indicated that longer periods of protection resulted when the concentration was increased. Doubling the dosage should not greatly increase the cost of treatment because the cost of a chemical is only a small part of the total cost of treating a building.

The following chemical formulations, listed in alphabetical order, are the best of those tested thus far and are recommended for treatment of the soil to prevent termite attack. Tests of these and other chemicals are still in progress. The recommendations are subject to change as more results become available.

1. **Aldrin, 0.5 percent in water emulsion or oil solution.** Under test for 11 years and still 100 percent effective. This chemical has not been tested as extensively as the others, but it has given equally good results in a limited number of tests.
2. **Benzene hexachloride, 0.8 percent gamma in water emulsion or oil solution.** Under test for 12 years; 100 percent effective for first 8 years; 80 percent effective for 9 to 10 years.
3. **Chlordane, 1.0 percent in water emulsion or oil solution.** Under test for 12 years and still 100 percent effective.
4. **DDT, 8 percent in oil.** Under test for 11 years and 100 percent effective for 5 years; 90 percent effective for 6 to 11 years.
5. **Dieldrin, 0.5 percent in water emulsion or oil solution.** Under test for 11 years and still 100 percent effective.
6. **Heptachlor, 0.5 percent in water emulsion.** Under test for 8 years and still 100 percent effective.

Water emulsions generally are more suitable for soil treatment than oil solutions because the emulsions are cheaper and usually are not injurious to plants. Retail prices of chemicals vary; therefore, obtain prices from different sources before buying.

Oil solutions should be prepared with No. 2 fuel oil or its equivalent. Do not use them under concrete slabs; they may damage vapor barriers, creep through the slabs, and affect floor coverings above. Generally, they should be used only for treatment around the walls, piers, pipes, etc., within foundations in crawl-space areas.

Wells located near or beneath buildings may become contaminated through subsurface drainage. Carefully consider this danger before applying chemicals to the soil.

*If wells are located outside of buildings* and extreme hazards of termite attack exist, protection can be obtained by mechanically blocking their passage from soil to wood. This can be done by using



a poured concrete wall devoid of crevices, or a masonry wall with all mortar joints well filled. The expansion joints between concrete floors and these two types of walls in slab-on-ground and basement houses, should be filled with hot coal-tar pitch or a bituminous rubberoid sealer. The exterior of masonry walls in houses with basements should be damp-proofed with one of the above materials, or faced with a layer of dense, water-repellent cement.

*If wells are located under buildings* and the drinking water may be endangered, do not use soil chemicals at all. Instead, use mechanical blocking methods. If these are used, make periodic inspections to detect the presence of termites.

Do not apply chemicals to water-soaked or frozen soils.

Most of the chemicals mentioned can be obtained from agricultural stores and chemical distributors.

### *Preparation of Chemicals for Soil Treatment*

A soil chemical is economical and most easily prepared when purchased in the form of a *liquid concentrated solution*. The concentrate is sold according to the percentage, or weight in pounds per gallon, of the toxicant it contains. These percentages and weights vary according to the amount of toxicant present in the concentrates of the different chemicals. Each concentrate contains an emulsifier to make it mixable with either water or oil, and must be diluted before it is ready for use.

Directions for diluting the concentrated solutions to the strength of the finished emulsion or oil solution recommended are usually given on the container. If such directions are not given, consult the information furnished below.

**Aldrin** is usually sold as a liquid concentrate containing either 2 or 4 pounds per gallon of the technical grade chemical. To prepare a 0.5 percent strength, ready for use, dilute 1 gallon of the 2 pound concentrate with 47 gallons of water, or 1 gallon of the 4 pound material with 95 gallons of water. This makes 48 gallons of the 0.5 water emulsion from the lower concentrate and 96 gallons from the higher one. The rate of dilution is 1 to 47 and 1 to 95 respectively, regardless of the unit of measure used (gallon, pint, etc.).

**Benzene hexachloride (BHC)** is frequently sold as a liquid concentrate containing 12 percent gamma isomer (the part that is toxic to insects). To prepare an 0.8 percent strength, ready for use, dilute 1 gallon of the concentrate with 15 gallons of water.

**Chlordane** is sold as 46-48 or 72-74 percent liquid concentrate. To prepare a 1 percent water emulsion, ready for use, dilute 1 gallon of the 46 percent concentrate with 48 gallons of water, or 1 gallon of the 72 percent material with 99 gallons of water.

**Dieldrin** is usually sold as a liquid concentrate containing 1.5 pounds per gallon of the technical grade chemical. To prepare an 0.5 percent strength, ready for use, dilute 1 gallon of the concentrate with 36 gallons of water.

**DDT** is often sold as 25 or 35 percent liquid concentrate. To prepare an *oil solution* containing 8.0 percent of the chemical, ready for use, dilute 1 gallon of the 25 percent concentrate with 2 gallons of No.

2 fuel oil, or 1 gallon of the 35 percent concentrate with 3.5 gallons of the oil.

**Heptachlor** is sold as a liquid concentrate containing 2 or 3 pounds per gallon of the actual chemical. To prepare an 0.5 percent strength, ready for use, dilute 1 gallon of the 2 pound concentrate with 48 gallons of water, or 1 gallon of the 3 pound concentrate with 72 gallons of water.

### *Precautions in Use of Chemicals*

**WARNING**—Because of fire hazard, take care to avoid open flames or electric sparks when applying flammable chemicals, such as mixtures containing fuel oil, in a confined, poorly ventilated space. When treating poorly ventilated crawl spaces, use an exhaust fan near the access area.

Do not allow chemicals to come in contact with the skin or eyes. If they do, wash the skin immediately with warm soapy water, and the eyes with a solution of boric acid (1 teaspoonful per glassful of warm water), or with plenty of water. Call a doctor if necessary. If the chemical is being applied with pressure through holes in walls and piers, use a cellulose acetate face guard so that the liquid cannot splash back onto the face. Do not store, or leave unguarded while treating, opened containers of chemicals where children or pets can get to them. Dispose of empty containers as directed on the label. Do not breathe fumes, spray mist, or dust from any of these insecticides or their concentrates.

Do not apply chemicals to the soil where there is a possibility of poisoning drinking water.

### *Rates of Application*

*Slab-on-ground houses.*—Soil that is to be covered with a concrete slab should be treated as follows:

1. Apply 4 gallons of chemical per 10 linear feet to the soil in critical areas under the slab, such as along the inside of foundation walls, along both sides of interior partition foundation walls, and around plumbing.
2. Apply 1 gallon of chemical per 10 square feet as an overall treatment under the slab and attached slab porches and terraces where the fill is soil or unwashed gravel.
3. Apply 1½ gallons of chemical per 10 square feet to those areas where the fill is washed gravel or other coarse absorbent material, such as cinders.
4. Apply 4 gallons of chemical per 10 linear feet of trench along the outside edge of the building *after all grading is finished*.

*Crawl-space houses.*—The soil under or around this type of construction should be treated as follows:

1. Apply 4 gallons of chemical per 10 linear feet of trench along the inside of foundation walls, along both sides of interior partitions, and around pier and plumbing. Do not apply an overall treatment in crawl spaces.
2. Apply 4 gallons per 10 linear feet of trench for *each foot of depth from grade to footing* along the outside of foundation walls, including the part beneath entrance platforms, porches, etc.
3. Apply 4 gallons per 10 linear feet along the inside and outside of foundation walls of porches.

4. Apply 1 gallon per 10 square feet of soil surface as an overall treatment, *only where the attached concrete platform and porches are on fill or ground.*

**Basement houses.**—Rates of application for this type of construction are the same as those recommended for slab-on-ground and crawl-space construction. Treat the basement floor in the same way as a slab-on-ground house.

**Voids in masonry foundations.**—Treat all voids in masonry foundations with at least 2 gallons of chemical per 10 linear feet of wall, at or near the footing.

## Methods of Application

The object of chemical treatment of the soil is to provide a barrier through which termites cannot pass to reach a building.

**Slab-on-ground houses.**—Soon after the gravel or dirt fill has been made and tamped, treat the soil with a chemical *before covering with a concrete slab.* The chemical may be applied either

with a power sprayer or a sprinkling can. First apply the chemical in the critical areas, along the inside of the foundation walls, around plumbing, and in the wall voids. After this is done, give an overall treatment to the fill or ground (fig. 19). *The treated soil must not be disturbed between the time of application and the laying of the slab.*

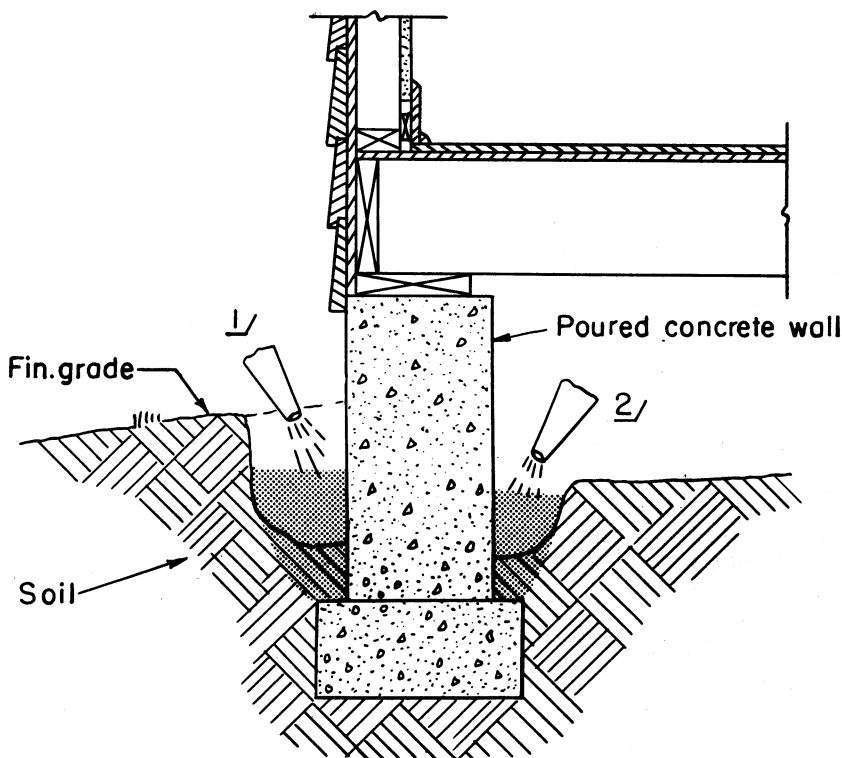
When all grading is completed, dig a trench 6 to 8 inches wide along the outside of the foundation. If the top of the footing is close to the surface, do not dig the trench below the top of it. If the top is more than 12 inches below the surface, make crowbar holes in the bottom of the trench as described below for basement houses. Mix the chemical with the soil as it is being replaced in the trench.

**Crawl-space and basement houses.**—To treat the soil along the exterior and interior walls of foundations with shallow footings, use the method described above for treating the exterior of slab-on-ground houses.



F-489265

Figure 19.—Chemical treatment of the soil, prior to pouring a concrete slab on the ground, protects wood in the building from termite attack. See figure 21 for details.



F-489276

**Figure 20.**—Application of chemical to crawl-space construction. Soil treatment (1) along outside and (2) inside foundation wall.

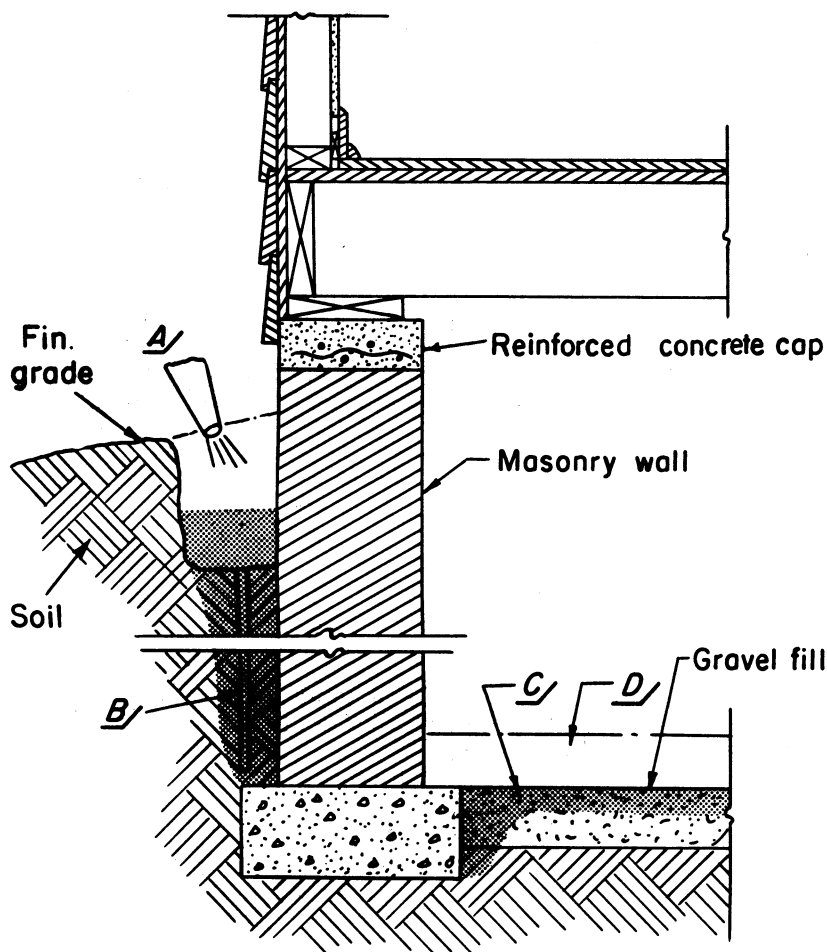
Where the footings are more than 12 inches deep and where large volumes of the chemical must be applied, make holes about 1 foot apart in the bottom of the trench, using a crowbar, pipe, or metal rod. Punch these holes down to the top of the footing (fig. 21, *B*). This will permit a better distribution of the chemical. The holes may need to be closer together in hard-packed clay soils than in light sandy ones.

Pour the chemical in the trench at the rate of 4 gallons per 10 linear feet *for each foot of depth* from the finished grade to the footing. This can be done by first pouring in some of the chemical and covering it with a 6-inch layer of soil. Then pour in some more of it and cover with another layer of soil. Repeat until the trench is filled and all of the chemical has been applied.

For the treatment of soil beneath concrete floors in basements (fig. 21), follow the same procedure as recommended above for the slab-on-ground type of construction.

### Periodic Inspection

Make periodic inspections of buildings for evidence of termite attack. **This is simply good insurance and should be done regardless of how completely preventive measures were employed in construction.** The frequency of such inspections will depend on the



F-489277

**Figure 21.**—Application of chemical to the soil in and around a house with a full basement. *A*, Soil treatment along outside of the foundation. *B*, Pipe and rod hole from bottom of trench to the top of the footing to aid distribution of the chemical. *C*, Treatment of fill or soil beneath a concrete floor in basement. *D*, Position of concrete slab after the chemical has been applied.

abundance of termites in the area and the type of construction. In areas of extreme hazard, inspections should be made at least twice a year. If termites are found, control measures described in the following section should be employed.

## CONTROL OF TERMITES IN BUILDINGS

Ridding existing structures of termite infestations and making them resistant to future infestation is a major problem in termite control. Generally, buildings become infested because little or no attention had been paid during their construction to measures that would have made them resistant to termites. It is in such buildings that termites cause heavy losses each year.

To control termite infestations in existing buildings, observe the same principles that are recommended for the prevention of infestation during the construction of new buildings. That is, eliminate conditions which favor the development of termite colonies in the soil and permit the passage of termites from the soil to the woodwork of the building. This is important, because termites in the woodwork of a building will die if they are prevented from maintaining contact with the soil or other sources of moisture.

## Sanitation and Structural Control Methods

Sanitation and structural control measures should be given first consideration in the control of existing infestations. These control measures include the following:

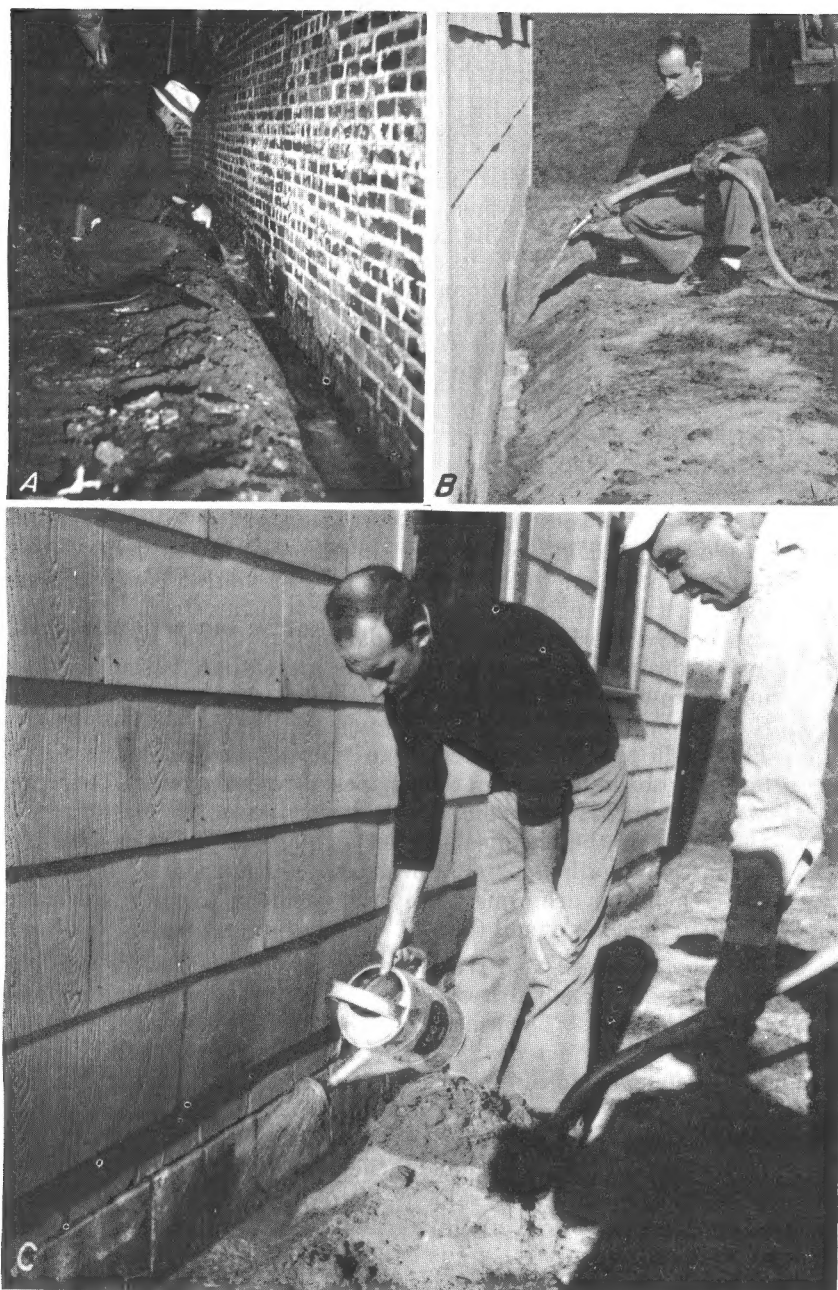
1. Remove all wood, including form boards and other debris containing cellulose, from underneath and adjacent to buildings with crawl spaces.
2. Remove other wooden units, such as trellises, that connect the ground with the woodwork on the exterior of the building. Replace them in a manner to break these contacts. Impregnate wood piers and posts that will be driven into the soil. Use an approved preservative applied by a standard pressure process.
3. Replace heavily damaged (structurally weakened) sills, joists, flooring, etc. with sound material. Where possible, remove all soil within 18 inches of floor joists and 12 inches of girders (fig. 16).
4. Fill voids, cracks, or expansion joints in concrete or masonry with either cement grout, roofing-grade coal-tar pitch, or rubberoid bituminous sealers.
5. Provide adequate drainage and ventilation.

## Chemical Control Methods

Chemicals used to prevent subterranean termites from attacking buildings can also be used to check existing infestations in buildings. The chemicals to use, their concentrations, rates of application, method of preparation, and precautions to take when considering their use, are the same as those discussed on pages 19 to 24.

There are too many variations in construction to permit a detailed discussion here of chemical treatments for use in all possible situations. However, in applying these treatments, remember that *the purpose is to establish a barrier of treated soil adjacent to the foundation through which termites cannot pass* (fig. 22). Some of the main ways to control termites by chemical treatment in existing buildings are as follows:

1. *Slab-on-ground houses.*—Termite infestations in houses built with a slab on the ground present serious control problems. It is difficult to place chemicals in the soil beneath such floors where they will be effective. One way to do this is to drill holes about one-half inch in diameter through the concrete slab close to the points where the termites are, or where they may be entering. Space the holes about 6 inches away from the wall and approximately 12 inches apart to insure proper treatment of the soil underneath. *Take care to avoid drilling into plumbing and electric conduits.* Apply the chemical through the holes by any practical means available. Another way is to drill



W-489262, 489266, 489261

**Figure 22.**—Application of a chemical to the soil about the foundation of buildings infested with termites. A and B, Chemicals being applied to bottom of trench along inside and outside of foundations; C, where trenches are more than 6 inches deep, alternate the chemical with each 6-inch layer of soil. Note earth in shovel about to be added to chemical in trench.

through exterior foundation walls to the soil just underneath the slab and introduce the chemical through the holes. This method is complicated, however, and usually requires special equipment.

2. *Raised porches, terraces, and entrance slabs.*—Termite infestations occur frequently at porches, terraces, and entrance platforms. The most satisfactory way to control infestations at these places is to tunnel under the concrete slab *adjacent to the foundation wall*, all the way from one side to the other, and apply a chemical in the bottom of the tunnel, or trench. Remove all wood debris encountered in digging the tunnel. Place an access panel over the opening to permit annual inspections and additional soil treatments, if needed. Another way to treat this area is to drill holes 12 inches apart, either through the adjacent foundation wall *from within the crawl space or basement*, or through the entrance slab, and introduce the chemical through these holes.

3. *Crawl-space houses.*—Buildings with crawl spaces usually can be treated easily and effectively. In general, the following procedures can be used:

- a. Dig trenches 6 to 8 inches wide adjacent to and around all piers and pipes, and along both the inside (fig. 22, A) and outside of all foundation walls (fig. 22, B). For poured concrete foundations, the trench need be only 3 to 4 inches deep. For brick and hollow block masonry foundations, it should be at least 12 inches deep. Where the footing is more than 12 inches deep, make crowbar, pipe, or rod holes about 1 foot apart and extend them from the bottom of the trench to the footing (fig. 21, B). This will prevent termites from gaining hidden entry to the building through voids in these types of foundations. *The trench should never be dug below the top of the footing.*
- b. Pour one of the chemicals listed on page 20 into the trench at the rate of 4 gallons per 10 linear feet *for each foot of depth*. If the trench is a deep one, apply the chemical to alternate layers of about 6 inches of soil (22, C).

4. *Basement houses.*—To treat the soil along the outside walls of basements, dig a trench 6 to 8 inches wide and about a foot deep, *adjacent to the wall*. Then make crowbar, pipe, or rod holes about 1 foot apart that extend *from the bottom of the trench to the footing*. Pour the chemical into the trench at the rate of 4 gallons per 10 linear feet *for each foot of depth from grade to footing*, alternately replacing and treating 6-inch layers of soil.

5. *Houses with wells.*—In houses where wells are located close to or within foundation walls, the same principles of termite control apply as are recommended for their prevention. The main difference is that in existing buildings, wall voids can be treated directly with chemicals. Reinfestation of treated walls in basements can be prevented by first removing the earth along the outside of the wall from the finished grade to the footing. Then fill the mortar joints with dense mortar and waterproof the outer surface. Fill the mortar joints on the interior of the wall and seal the expansion joints where the wall and floor meet.



## OTHER INSECTS THAT DAMAGE WOOD IN BUILDINGS

Other insects attack the woodwork of buildings, too, and the damage may be mistaken for that caused by subterranean termites. The insects most commonly involved are drywood termites, powder-post beetles, and carpenter ants.

### Drywood Termites

Damage by drywood termites, one of the nonsubterranean forms, can be recognized by the presence of clean cavities cut across the grain in comparatively solid, dry wood. These cavities contain slightly compressed pellets of partially digested wood. Some of the pellets are pushed through tiny openings to the exterior where they often form in piles on the surface below. This termite also seals its entrance holes with a brownish-black, paper-thin secretion which may contain a few of the pellets.

In the United States, drywood termites usually are found in the Deep South, near the coast from Cape Henry, Va., to the Florida Keys, and westward along the coast of the Gulf of Mexico to the Pacific coast as far as northern California. There is a local infestation at Tacoma, Wash.

### Powder-Post Beetles

Damage by powder-post beetles is characterized by the presence of a fine-to-coarse powder that either is pushed to the exterior through small  $\frac{1}{8}$ -inch holes in the bark or wood, or is packed tightly in galleries made within the wood. Both hardwoods and softwoods are subject to infestation and damage. These beetles may attack wood used in the construction of buildings, or in the manufacture of seasoned wood products, such as furniture.

### Carpenter Ants

Damage by carpenter ants can be recognized by the presence of hollow, irregular, clean chambers, cut across the grain of partially decayed wood; also, by the presence of fine-to-coarse wood fibers which are removed from the chambers as the ants construct their nesting places. Solid wood adjacent to the nest also may be damaged. Columns and roofs of open porches, and wooden window sills of buildings are frequently attacked by these ants.

The work of drywood termites, powder-post beetles, and carpenter ants differs from that of subterranean termites, in that the wood is converted either to powder, shredded fibers, or compressed pellets. In contrast, subterranean termites eat all the wood substance they attack, leaving the sides of their cavities covered with small, grayish-brown specks of excrement. Their channels follow the grain of the wood, while the channels of most of the other insects mentioned are likely to cut across the grain.

## SELECTED LIST OF PUBLICATIONS

The following publications of the United States Department of Agriculture contain additional information on the habits, damage caused, and control of insects infesting buildings, and information on damage caused by decay. Such damage is often mistaken for that caused by subterranean termites. Unless noted otherwise, one copy of each publication can be obtained from the Office of Information, Department of Agriculture, Washington, D.C. 20250.

*Control of Nonsubterranean Termites.* U.S. Dept. Agr. Farmers' Bul. 2018, 16 pp. Sept. 1950.

*Use and Abuse of Wood in House Construction.* U.S. Dept. Agr. Misc. Pub. 358, 24 pp. 1939. For sale by Supt. of Documents, U.S. Govt. Printing Office, Washington 25, D.C. Price 20 cents.

*Preservative Treatment of Fence Posts and Farm Timbers.* U.S. Dept. Agr. Farmers' Bul. 2049, 33 pp. Revised April 1956.

*Wood Decay in Houses, How To Prevent and Control It.* U.S. Dept. Agr. Home and Garden Bulletin 73, 17 pp. October 1960.



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